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(54) **FLEXIBLE UNIFIED ARCHITECTURE FOR POINT-TO-POINT DIGITAL MICROWAVE RADIOS**

(71) Applicant: **ZTE (USA) INC.**, Richardson, TX (US)

(72) Inventors: **Ying Shen**, Chapel Hill, NC (US); **Edwin Nealis**, Cary, NC (US); **Aleksandr Semenyshev**, Apex, NC (US); **William Schmid**, Holly Spring, NC (US); **Shawn Walsh**, Cary, NC (US); **Thanh Nguyen**, Cary, NC (US); **Andrey Kochetkov**, Cary, NC (US); **Dong Hong Yom**, Cary, NC (US)

(73) Assignee: **ZTE (USA) Inc.**, Richardson, TX (US)

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H04L 5/16 (2006.01)
H04B 1/40 (2015.01)

(52) **U.S. Cl.**

CPC ***H04B 1/40*** (2013.01)

(58) **Field of Classification Search**

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USPC 375/219
See application file for complete search history.

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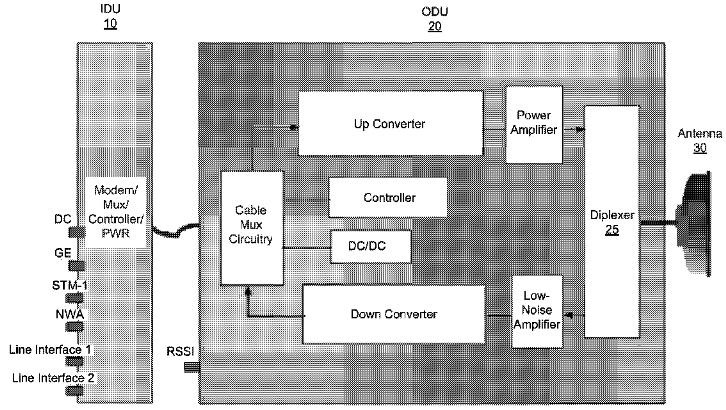
Primary Examiner — Nader Bolourchi
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

A transceiver used in a radio unit for wireless communication, comprises: a circuitry board including a transmitter and a receiver; a first connector on a first side of the circuitry board, wherein the first connector is configured to be connected to an interface card; a second connector on a second side of the circuitry board, wherein the second side is opposite the first side and the second connector is configured to be connected to a digital card via a flexible circuit; and a pair of transmit port and receive port located on the second side of the circuitry board, wherein the transmit port is coupled to the transmitter and the receive port coupled to the receiver, respectively. When the transceiver is part of a split-mount radio unit (SRU), the first connector is connected to the interface card and the second connector is not in use. When the transceiver is part of an all-outdoor radio unit (AOU), the second connector is connected to the digital card and the first connector is not in use.

16 Claims, 12 Drawing Sheets



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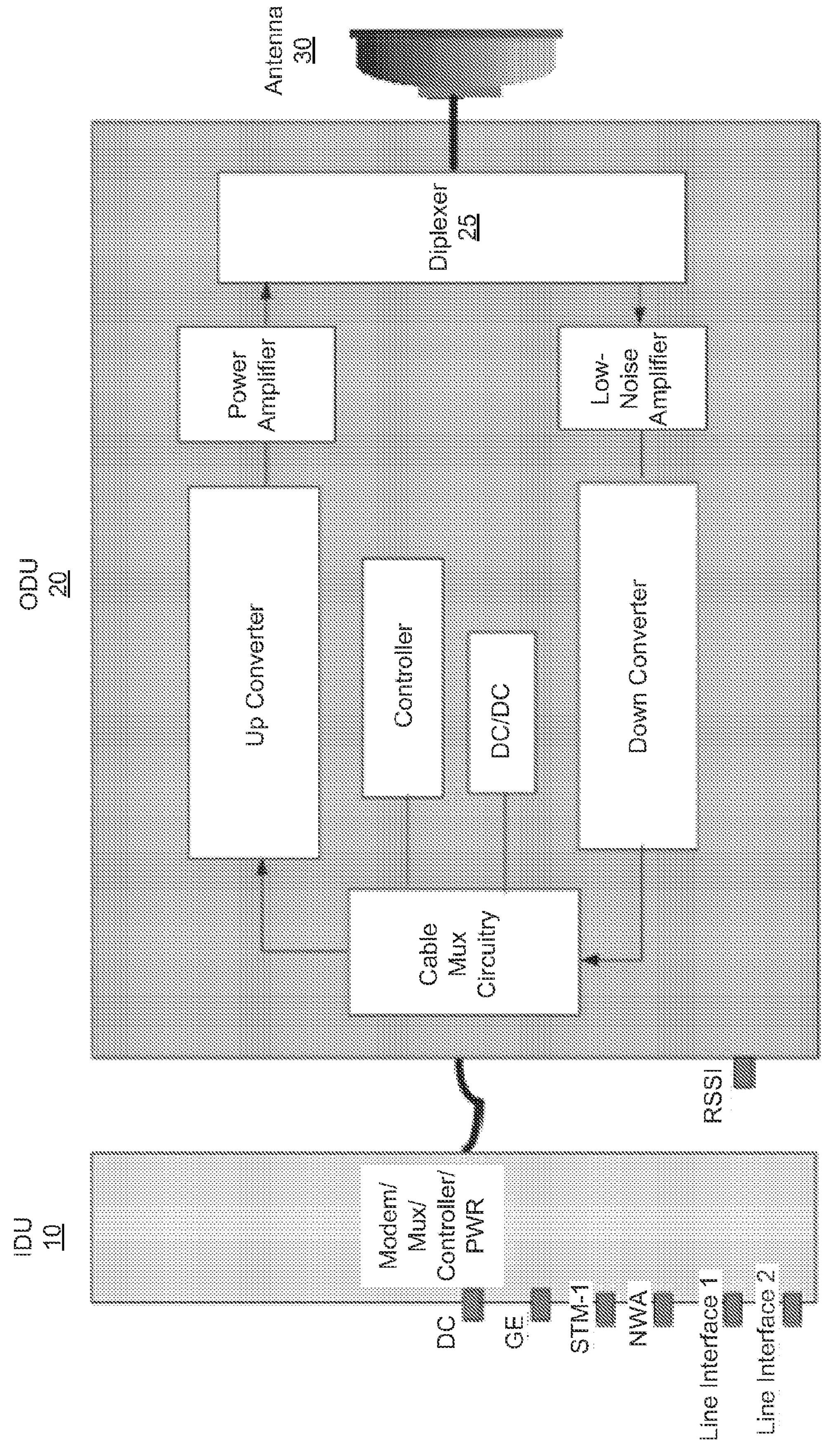
Antenna
30
ODU
20
Diplexer
25
Power Amplifier
Low-Noise Amplifier
Up Converter
Controller
DC/DC
Down Converter
Cable Mux Circuitry
RSSI
IDU
10
Modem/
Mux/
Controller/
PWR
DC
GE
STM-1
NWA
Line Interface 1
Line Interface 2

FIG. 1

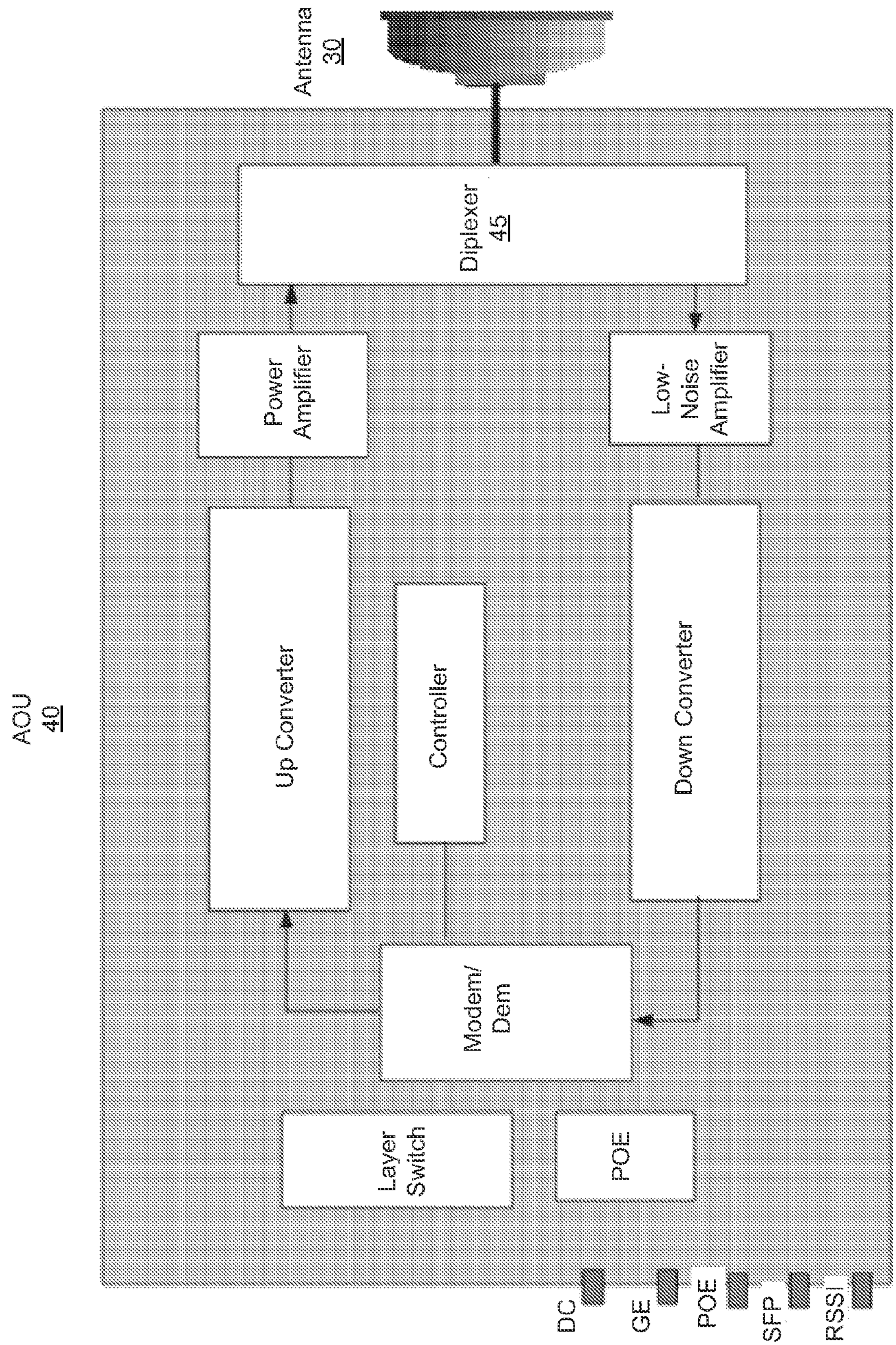
Antenna
30
AOU
40
Diplexer
45
Power Amplifier
Low-Noise Amplifier
Up Converter
Controller
Down Converter
Modem/ Dem
Layer Switch
POE
DC
GE
POE
SFP
RSSI

FIG. 2

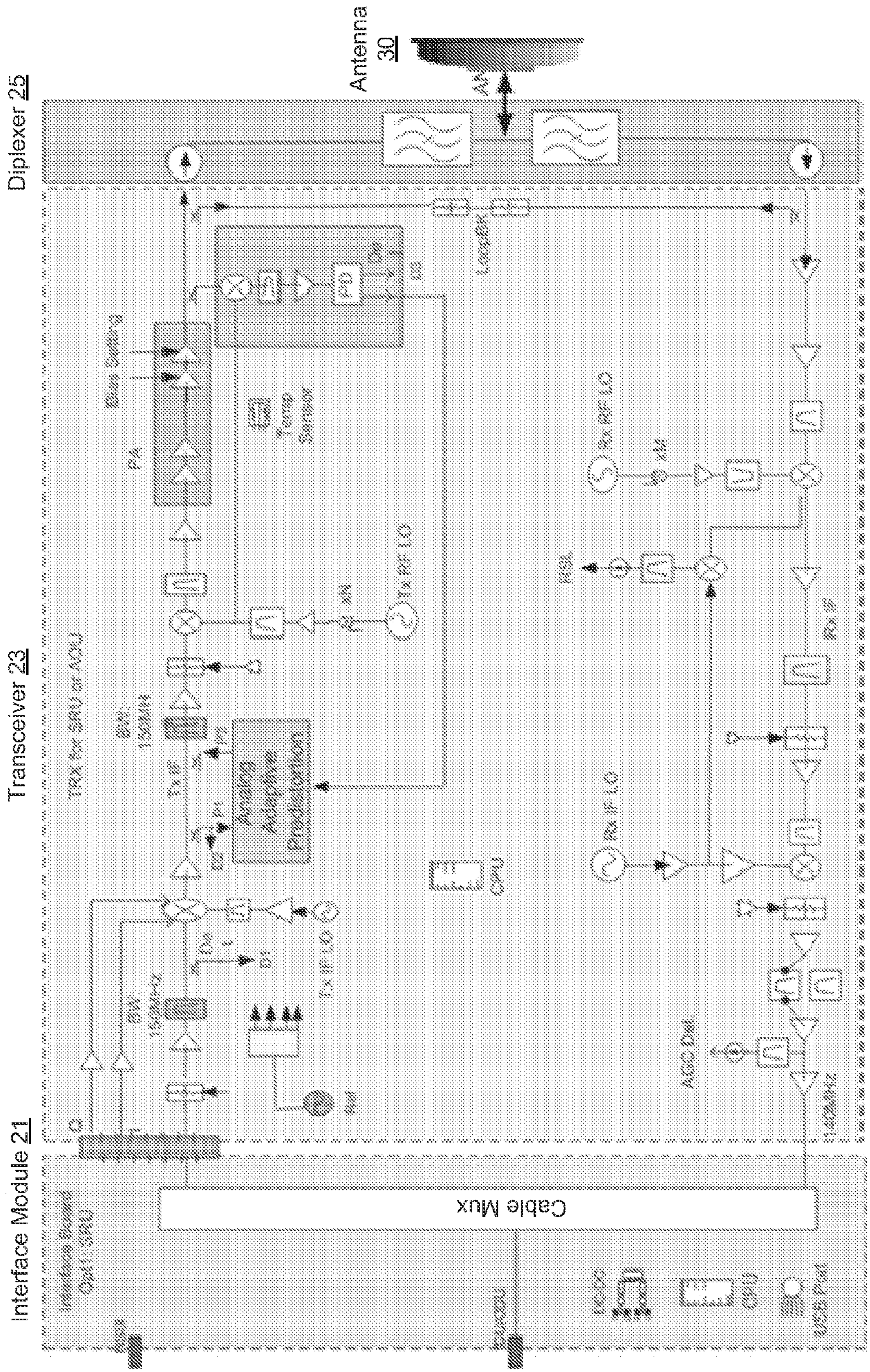
Antenna
30
Diplexer 25
Transceiver 23
Interface Module 21
Cable Mux
PA
Tx RF LO
Rx RF LO
Rx IF LO
Tx IF LO
Rx IF
CPU
AGC Det.
USB Port

FIG. 3

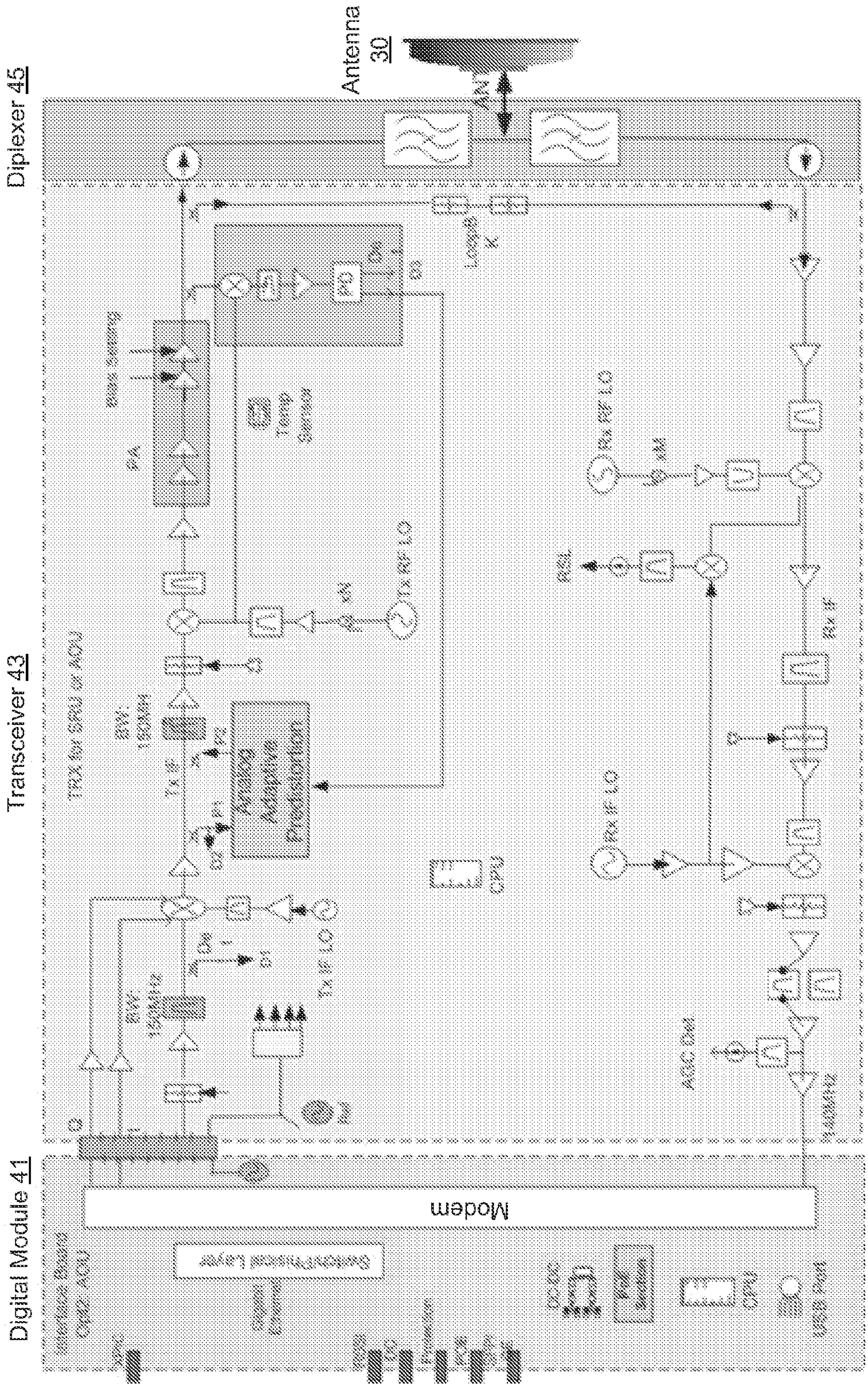
Digital Module 41
Transceiver 43
Diplexer 45
Antenna 30
Modem

FIG. 4

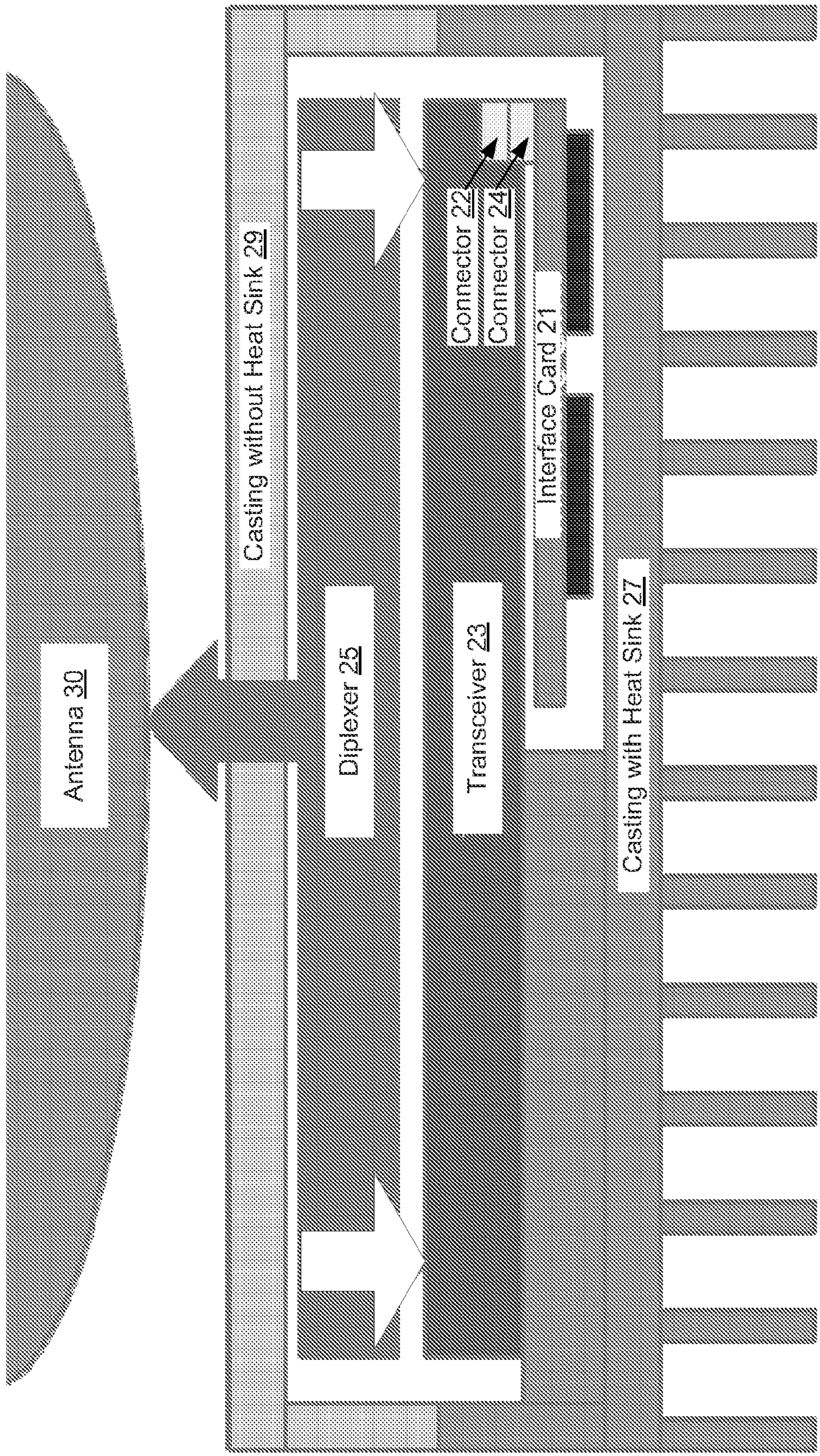
Antenna 30
Casting without Heat Sink 29
Diplexer 25
Transceiver 23
Connector 22
Connector 24
Interface Card 21
Casting with Heat Sink 27

FIG. 5

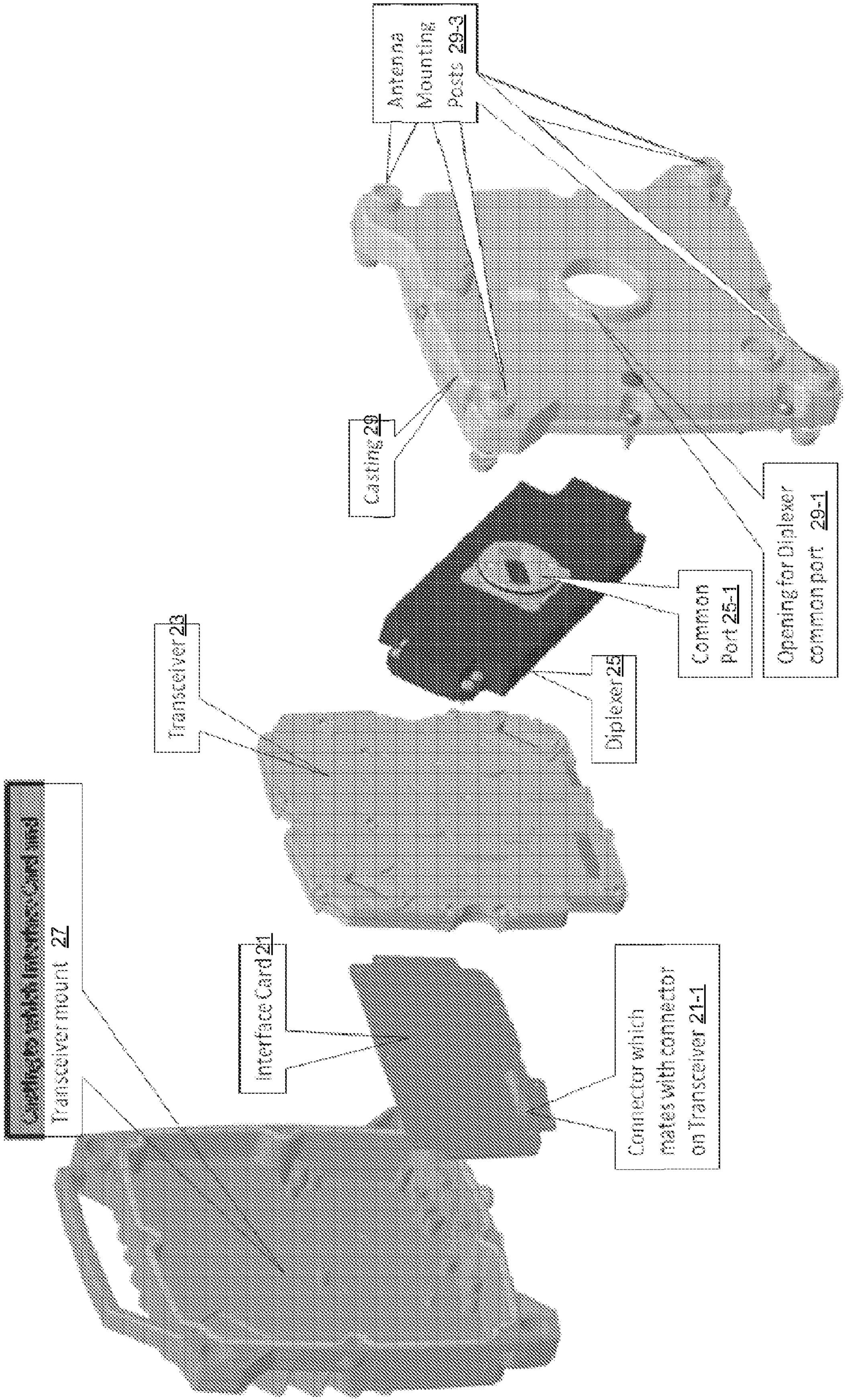
Antenna Mounting Posts 29-3
Casting 29
Opening for Diplexer common port 29-1
Common Port 25-1
Diplexer 25
Transceiver 23
Casting to which Interface Card and Transceiver mount 27
Interface Card 21
Connector which mates with connector on Transceiver 21-1

FIG. 6

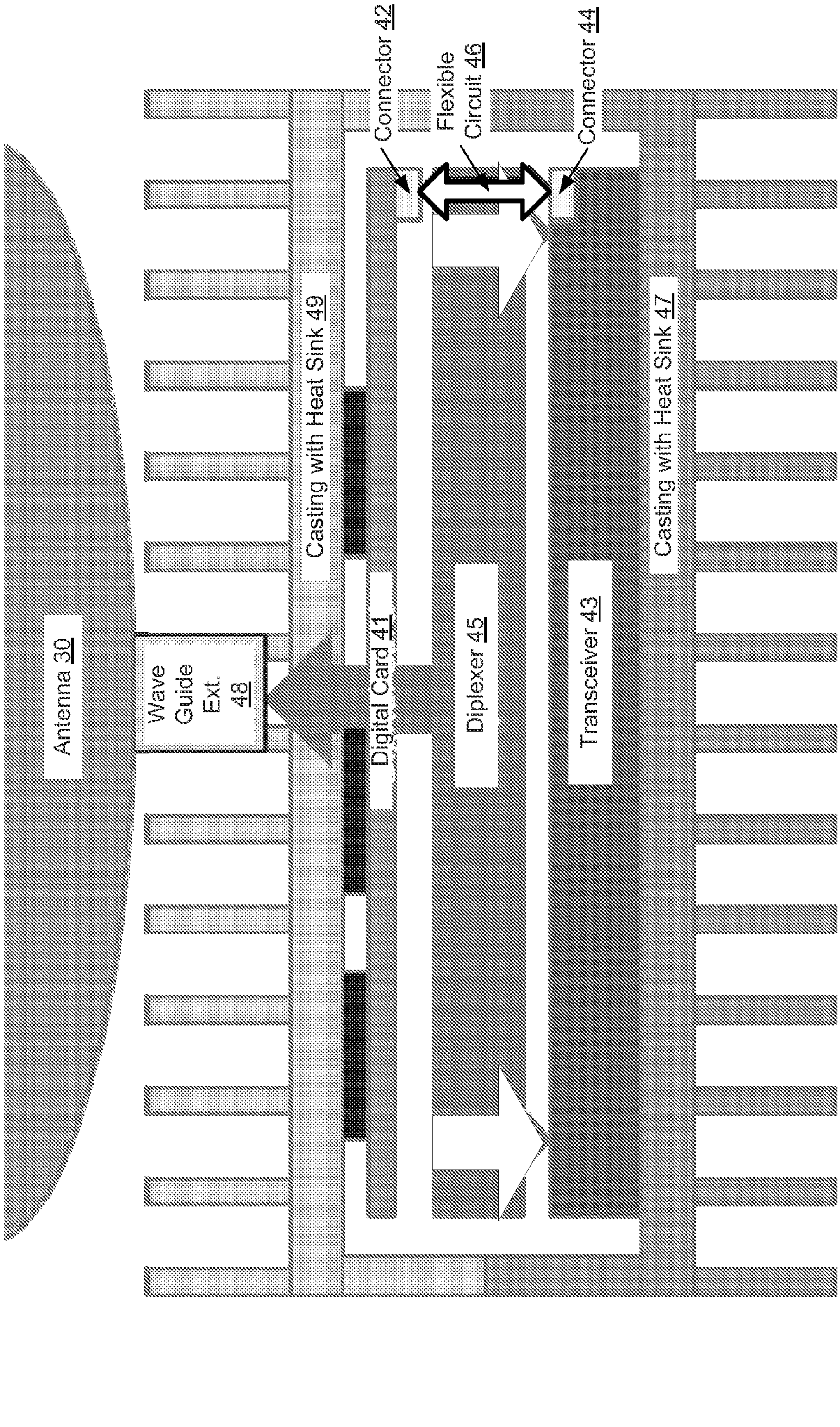
Connector 42
Flexible Circuit 46
Connector 44
Casting with Heat Sink 49
Antenna 30
Wave Guide Ext. 48
Digital Card 41
Diplexer 45
Transceiver 43
Casting with Heat Sink 47

FIG. 7

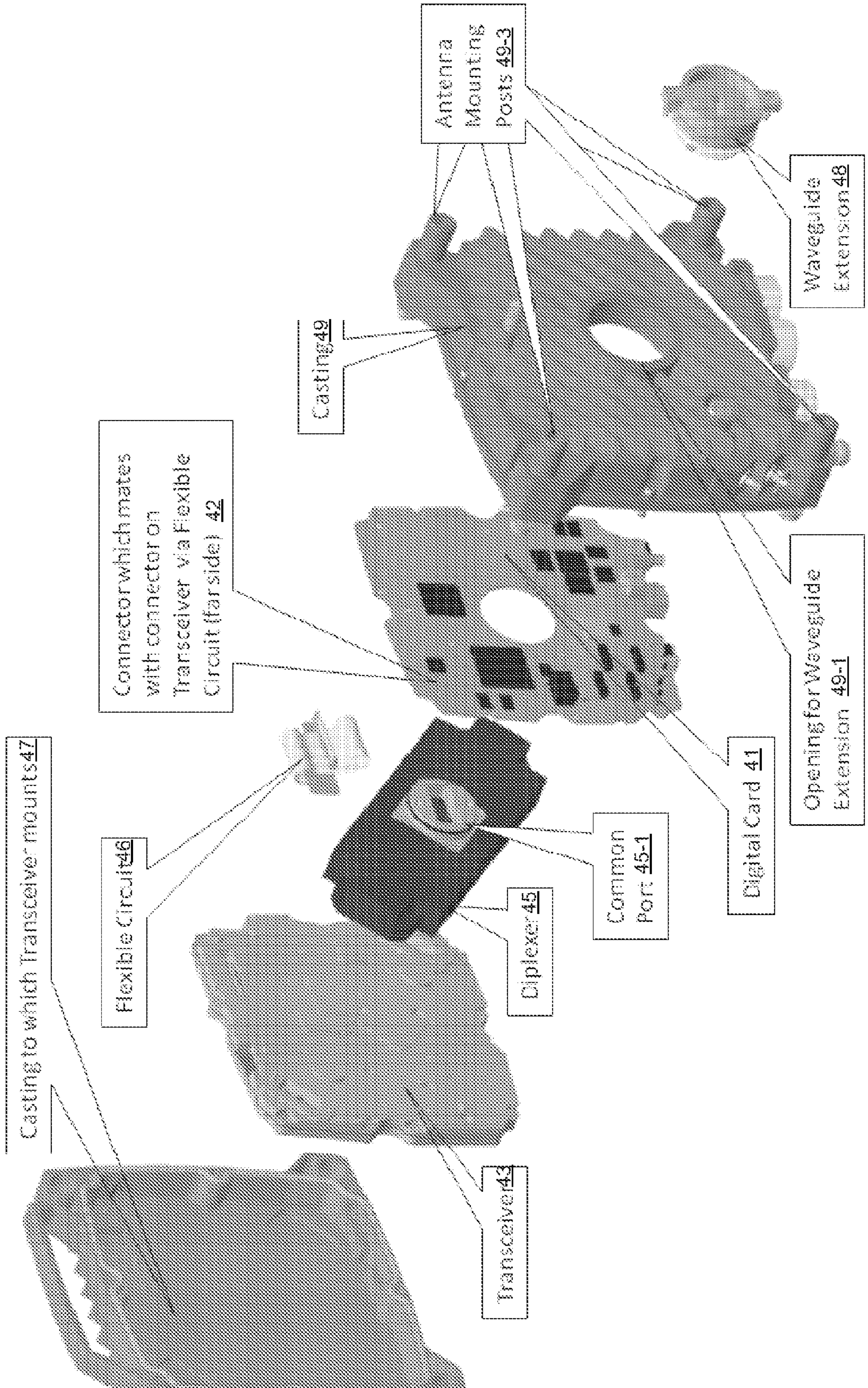
Antenna Mounting Posts 49-3
Waveguide Extension 48
Casting 49
Connector which mates with connector on Transceiver via Flexible Circuit (far side) 42
Opening for Waveguide Extension 49-1
Digital Card 41
Common Port 45-1
Flexible Circuit 46
Diplexer 45
Casting to which Transceiver mounts 47
Transceiver 43

FIG. 8

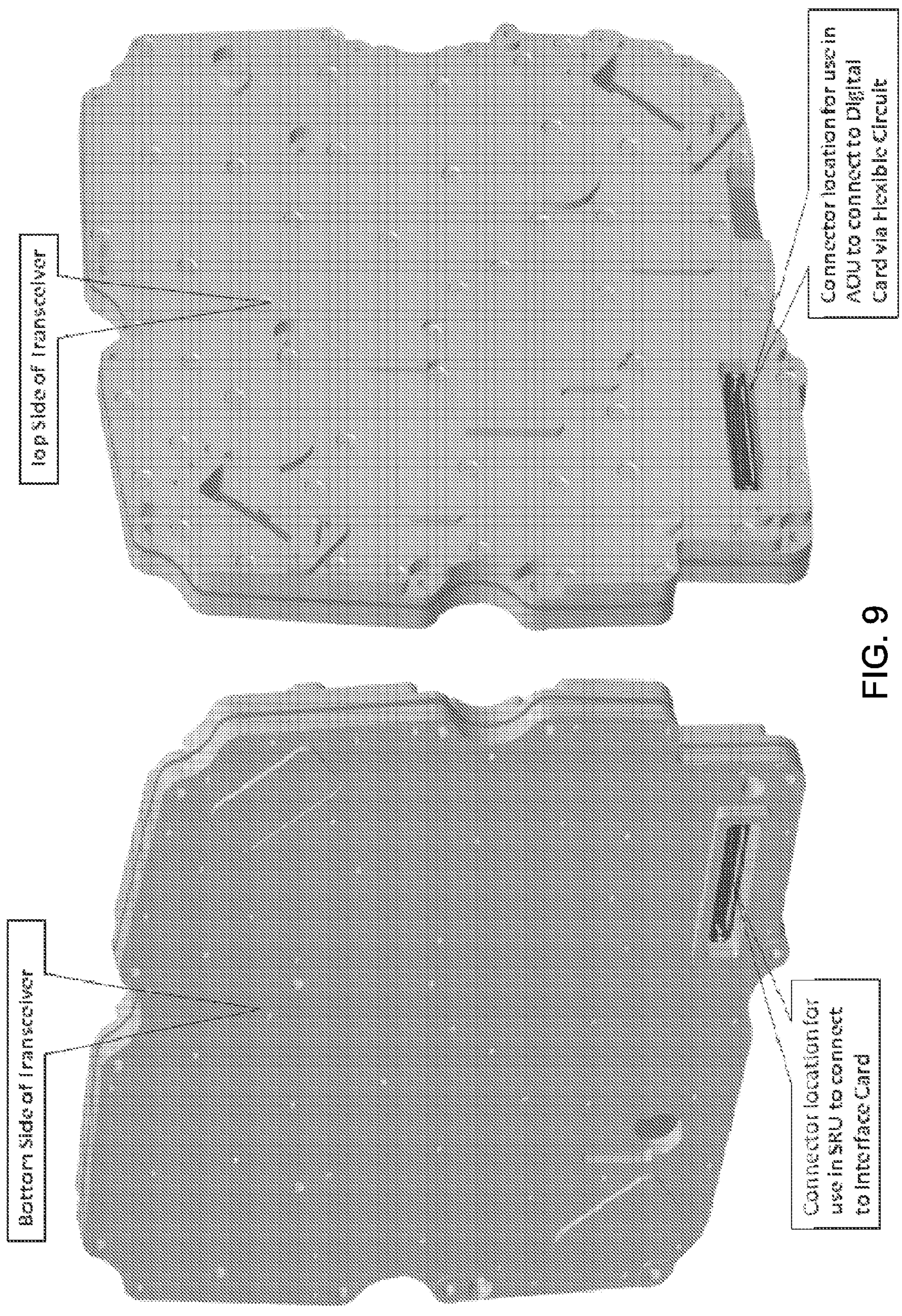
Top Side of Transceiver
Connector location for use in AOU to connect to Digital Card via Flexible Circuit
Bottom Side of Transceiver
Connector location for use in SRU to connect to Interface Card

FIG. 9

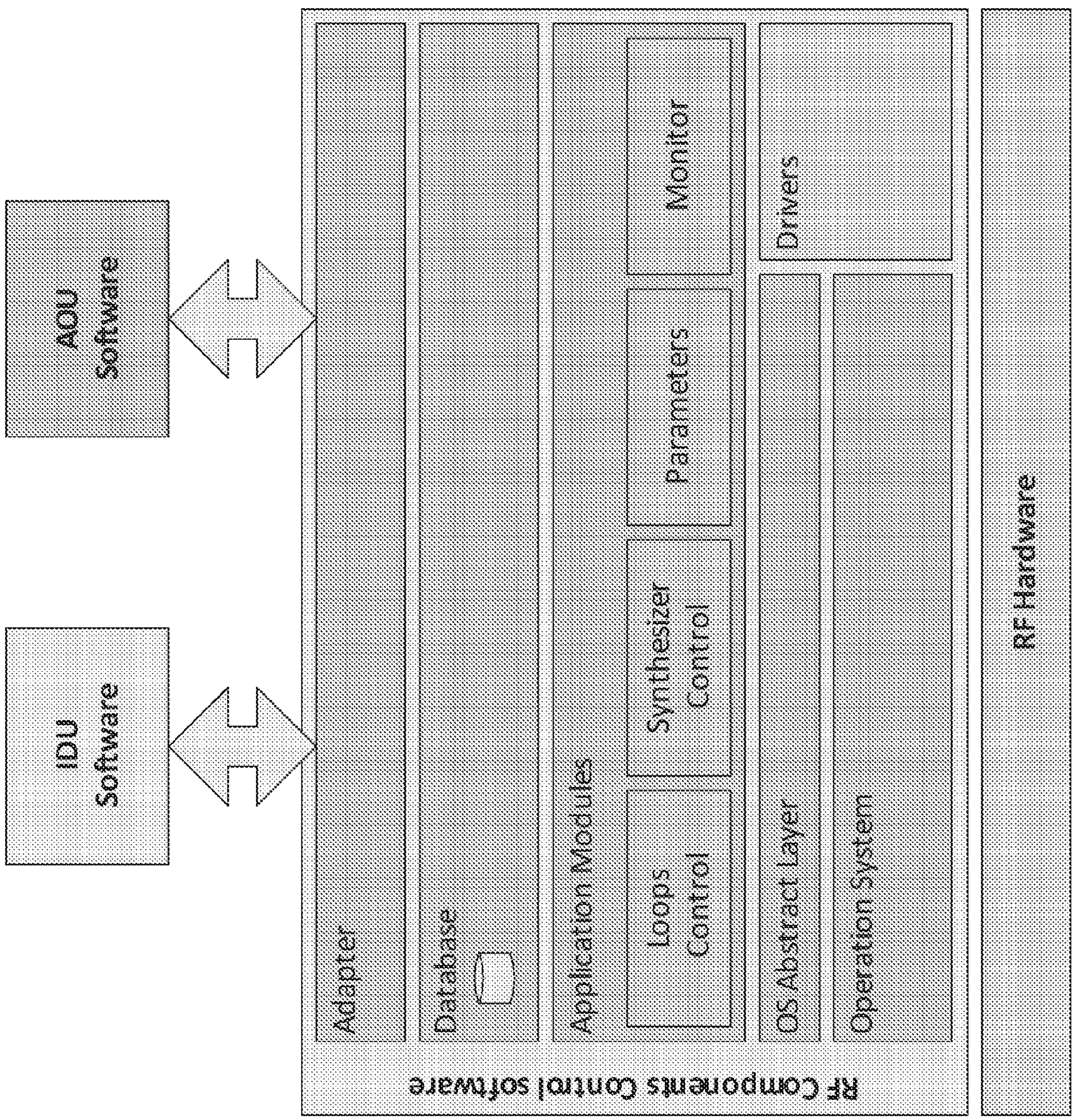
IDU Software
AOU Software
Adapter
Database
Application Modules
Loops Control
Synthesizer Control
Parameters
Monitor
OS Abstract Layer
Operation System
Drivers
RF Components Control software
RF Hardware

FIG. 10

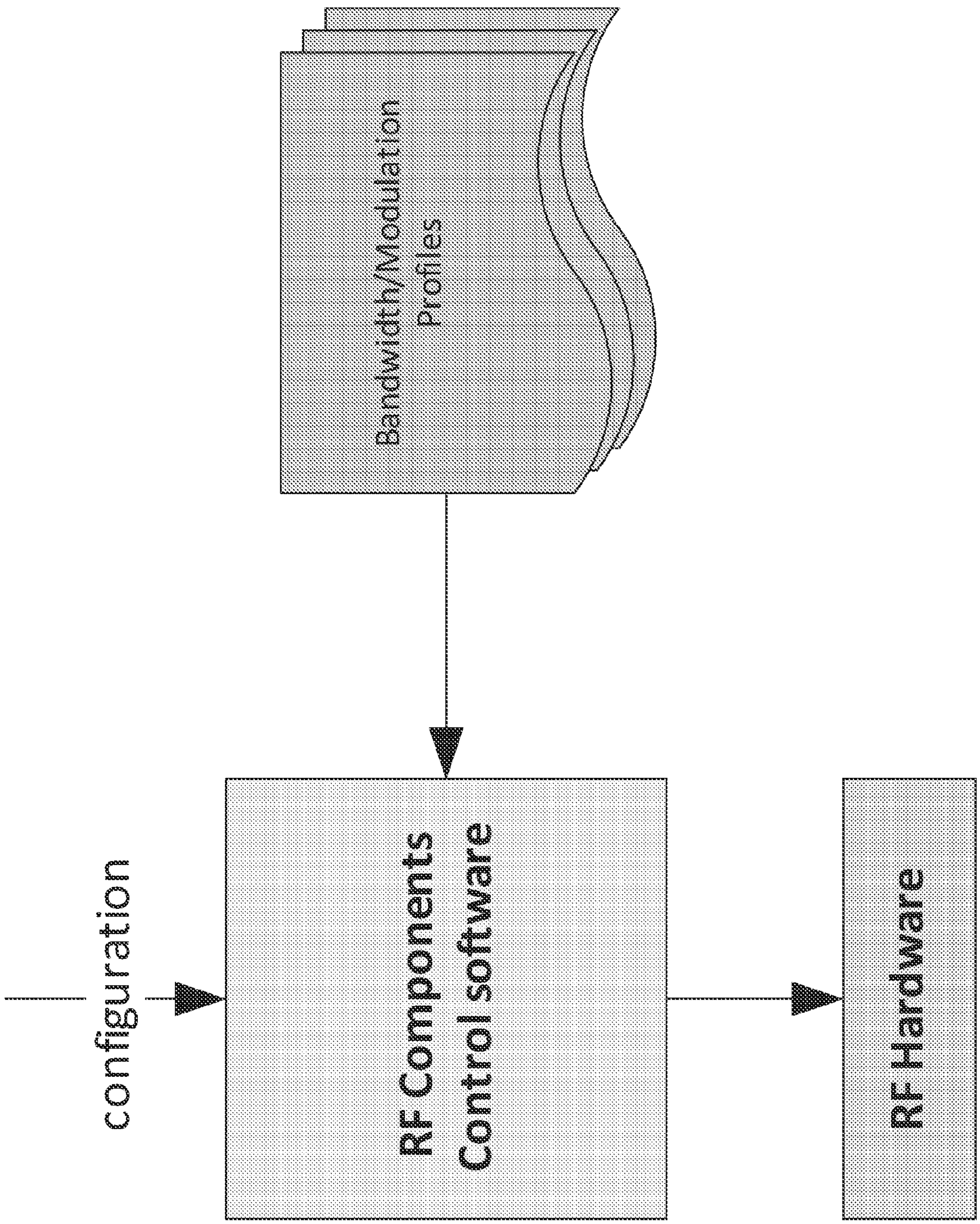
Bandwidth/Modulation Profiles
configuration
RF Components Control software
RF Hardware

FIG. 11

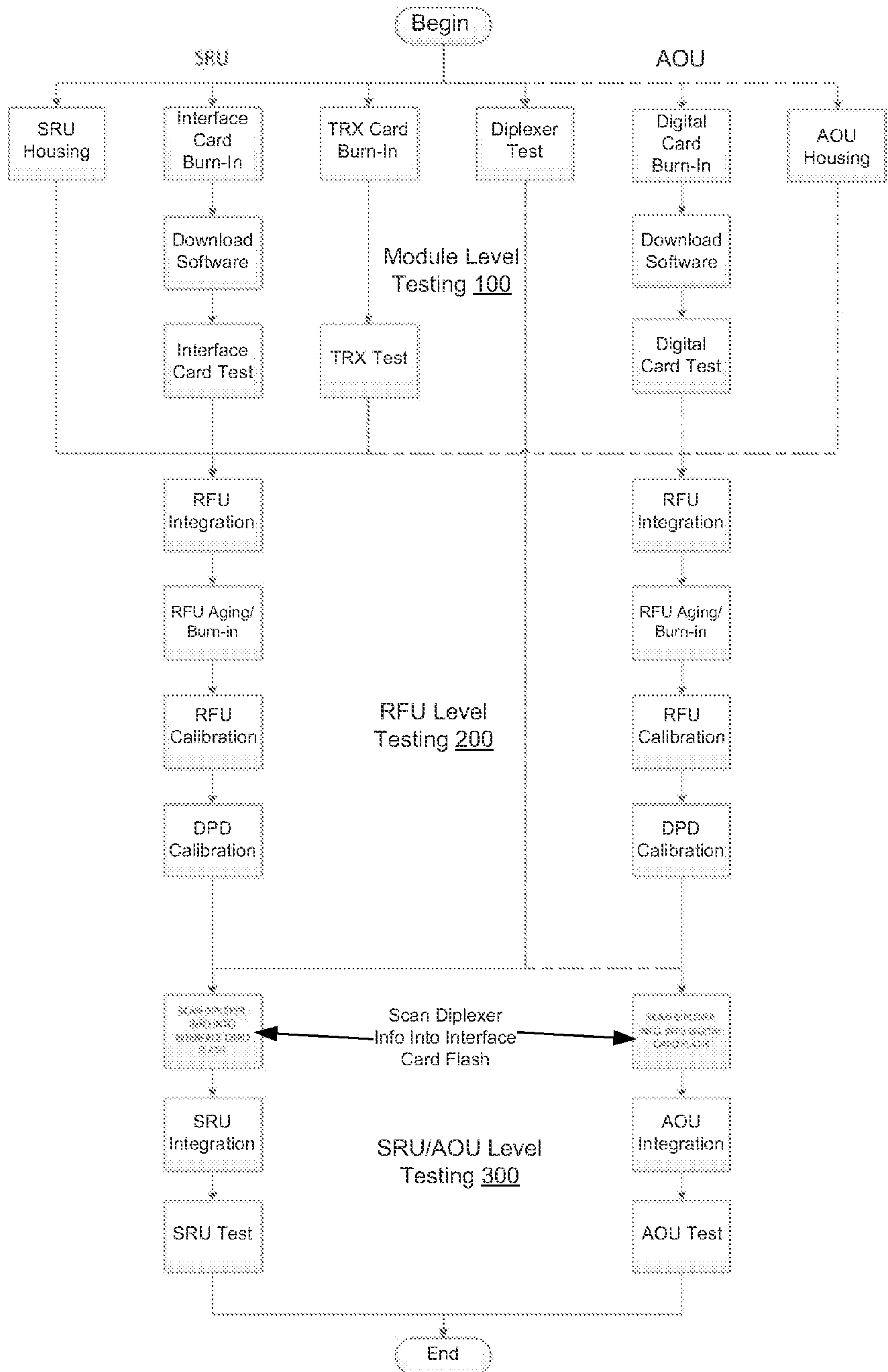
Begin
SRU
AOU
SRU Housing
Interface Card Burn-In
TRX Card Burn-In
Diplexer Test
Digital Card Burn-In
AOU Housing
Download Software
Module Level Testing 100
Download Software
Interface Card Test
TRX Test
Digital Card Test
RFU Integration
RFU Integration
RFU Aging/ Burn-in
RFU Aging/ Burn-in
RFU Calibration
RFU Level Testing 200
RFU Calibration
DPD Calibration
DPD Calibration
Scan Diplexer Info Into Interface Card Flash
SRU Integration
SRU/AOU Level Testing 300
AOU Integration
SRU Test
AOU Test
End

FIG. 12

FLEXIBLE UNIFIED ARCHITECTURE FOR POINT-TO-POINT DIGITAL MICROWAVE RADIOS

CROSS REFERENCE TO RELATED APPLICATIONS

This Application is a U.S. National Stage Application filed under 35 U.S.C. §371 of PCT Patent Application Ser. No. PCT/US2013/037610 filed on Apr. 22, 2013, which claims the benefit of and priority to U.S. Provisional Patent Application No. 61/637,788 filed on Apr. 24, 2012, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The presented invention relates to wireless communications and, in particular, to a flexible unified architecture for point-to-point digital microwave radios.

BACKGROUND

The fourth-generation (4G) wireless networks represent the next wave of mobile multimedia networks currently in development and the 4G Long Term Evolution (LTE) mobile networks are becoming a reality. Among others, the backhaul point-to-point microwave radios is a key part of this whole 4G network and plays an important role to the network success.

Point-to-Point Microwave Radios have a very wide range of frequency bands, typical licensed bands include 6 GHz, 7 GHz, 8 GHz, 10 GHz, 11 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 26 GHz, 28 GHz, 32 GHz, 38 GHz and 42 GHz, plus unlicensed bands at sub 6 GHz, 60 GHz and the latest light license band of E-band (71-86 GHz). The covered modulations include QPSK, 16 QAM, 32 QAM, 64 QAM, 128 QAM, 256 QAM and extends to latest 512 QAM and 1024 QAM, and future even higher modulation such as 2048 QAM and 4096 QAM. The covered bandwidth includes popular international bandwidth of 3.5 MHz/7 MHz/14 MHz/28 MHz/56 MHz and North America's FCC bands of 5 MHz/10 MHz/20 MHz/30 MHz/40 MHz/50 MHz and coming new 112 MHz, 250 MHz and 500 MHz channel bandwidths.

In order to support these different radio configurations, frequency bands, modulations, capacity offerings, it is becoming more and more important to develop a point-to-point microwave radio with common mechanics, common interface to antenna, common software, and common automatic test equipment (ATE) for achieving such goals as low cost of deployment and maintenance and short time to market, etc. Moreover, both the operators and equipment vendors/manufacturers also prefer that their microwave equipment complies with a flexible unified architecture that supports various platforms, which is scalable, interchangeable, and shares common elements for all capacities and frequency bands.

SUMMARY

According to some implementations, a transceiver used in a radio unit for wireless communication comprises: a circuitry board including a transmitter and a receiver; a first connector on a first side of the circuitry board, wherein the first connector is configured to be connected to an interface card; a second connector on a second side of the circuitry board, wherein the second side is opposite the first side and the second connector is configured to be connected to a digital card via a flexible circuit; and a pair of transmit port and

receive port located on the second side of the circuitry board, wherein the transmit port is coupled to the transmitter and the receive port coupled to the receiver, respectively.

According to some implementations, a split-mount radio unit comprises an indoor unit and an outdoor unit that is connected to the indoor unit via a cable. The outdoor unit further includes: an enclosure including a pair of first and second castings, wherein the first casting includes a heat sink; an interface card mounted on an inside surface of the first casting, wherein the interface card includes a connector on a surface opposite the inside surface of the first casting; a transceiver mounted on the inside surface of the first casting, wherein the transceiver includes a first connector on a first side of the transceiver facing the inside surface of the first casting and a second connector and a pair of transmit port and receive port on a second side opposite the first side of the transceiver, the first connector is connected to the connector of the interface card and the second connector is not in use; a diplexer including a pair of transmit port and receive port on a surface facing the second side of the transceiver and a common port on an opposite surface facing an inside surface of the second casting, wherein the pair of transmit port and receive port of the diplexer are connected to the corresponding pair of transmit port and receive port of the transceiver; and an antenna outside the enclosure, wherein the antenna includes a port connected to the common port of the diplexer through a hole of the second casting.

According to some implementations, an all-outdoor radio unit comprises: an enclosure including a pair of first and second castings, wherein each of the pair of first and second castings includes a heat sink; a transceiver mounted on an inside surface of the first casting, wherein the transceiver includes a first connector on a first side of the transceiver facing the inside surface of the first casting and a second connector and a pair of transmit port and receive port on a second side opposite the first side of the transceiver; a diplexer including a pair of transmit port and receive port on a first side of the diplexer facing the inside surface of the first casting and a common port on an opposite side of the diplexer facing an inside surface of the second casting, wherein the pair of transmit port and receive port of the diplexer are connected to the corresponding pair of transmit port and receive port of the transceiver; a digital card mounted on the inside surface of the second casting, wherein the digital card includes a hole near its center and a connector on a surface opposite the inside surface of the second casting for connecting to the second connector of the transceiver via a flexible circuit; and an antenna outside the enclosure, wherein the antenna includes a port connected to the common port of the diplexer via a waveguide connection through a hole of the second casting and the hole near the center of the digital card, respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

Different aspects of the present invention as well as features and advantages thereof will be more clearly understood hereinafter as a result of a detailed description of implementations of the present invention when taken in conjunction with the accompanying drawings, which are not necessarily drawn to scale. Like reference numerals refer to corresponding parts throughout the several views of the drawings.

FIG. **1** depicts a block diagram of a typical split-mount radio unit (SRU).

FIG. **2** depicts a block diagram of a typical all-outdoor radio unit (AOU).

FIG. 3 depicts a more detailed block diagram of the SRU according to some implementations of the present invention.

FIG. 4 depicts a more detailed block diagram of the AOU according to some implementations of the present invention.

FIG. 5 depicts a simplified cross-sectional view of the SRU according to some implementations of the present invention.

FIG. 6 depicts a simplified exploded view of the SRU according to some implementations of the present invention.

FIG. 7 depicts a simplified cross-sectional view of the AOU according to some implementations of the present invention.

FIG. 8 depicts a simplified exploded view of the AOU according to some implementations of the present invention.

FIG. 9 depicts the top and bottom of a transceiver and the position of the connector for use in the SRU and AOU according to some implementations of the present invention.

FIG. 10 depicts a block diagram of RF components control software according to some implementations of the present invention.

FIG. 11 depicts a block diagram illustrating a process of the RF components control software tuning with different bandwidth/modulation profiles for different system configurations according to some implementations of the present invention.

FIG. 12 depicts a flow chart illustrating a testing and integration workflow for both the SRU and the AOU according to some implementations of the present invention.

DESCRIPTION OF EMBODIMENTS

Reference will now be made in detail to implementations, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous non-limiting specific details are set forth in order to assist in understanding the subject matter presented herein. It will be apparent, however, to one of ordinary skill in the art that various alternatives may be used without departing from the scope of the present invention and the subject matter may be practiced without these specific details.

The point-to-point microwave radios in its path transition from all indoor radios, to split mount radios and now to all outdoor radios. In the past, most radios used in Point to Point microwave wireless were comprised of radio units that were mounted indoors. These radios hardware platforms required radios that were rack mounted indoors and had to use large coax or Elliptical Waveguide running out from the indoor radio unit up the tower (or to the roof top), connecting the antenna. The industry later came out with a split-mount design radio system consisting of an indoor modem unit "IDU" and an outdoor RF Unit "ODU" that mounts the actual radio RF component hardware directly onto the back of the antenna. Today the industry has migrated to All Outdoor radio Unit systems "AOU" comprised of a single outdoor unit mounted to the back of the antenna. These AOU's contain the RF components, modems, and network interface. The connection between the AOU and the network switch is typically outdoor shielded twisted pair (CAT-5e) or fiber. The AOU design has far greater advantages over the indoor radio or IDU+ODU spit mount designs.

FIG. **1** depicts a block diagram of a conventional split-mount radio unit (SRU), including three basic parts: an indoor unit (IDU) **10**, an outdoor unit (ODU) **20** and an antenna **30**.

FIG. **2** depicts a block diagram of a typical all-outdoor radio unit **40** (AOU). AOU **40** integrates modem, mux, controller into one unit. Since AOU **40** is an outdoor unit, it supports a standard IP Ethernet interface with power over Ethernet (POE) feature and supports optional fiber interface. AOU **40** also has an RSSI port for antenna alignment purpose.

An effective design for both SRU and AOU becomes a challenge for all radio equipment vendors. This invention discloses many ideas for both product families, SRU and AOU, so as to share design, hardware, software, calibration, test flow, test stations, antenna interface, and mounting mechanics etc., and reduce the design, manufacturing and time to market cycles.

FIG. **3** depicts a more detailed block diagram of the SRU according to some implementations of the present invention. In some implementations, the radio unit includes three basic modules: a diplexer **25**, a transceiver **23** and an interface card **21**. As shown in FIG. **4**, the SRU and the AOU share the same transceiver and diplexer. The only change in the AOU is to change the interface card **21** to a digital card **41**.

Note that the transceiver, as a key module for both product families (SRU and AOU), has the following features:

a. Transceiver supports both I/Q and Tx IF interfaces. In the AOU, the transceiver uses I and Q signals. In the SRU, the transceiver uses Tx IF signal.

b. Transceiver has a total of three detectors in the transmitter chain, D**1**, D**2** and D**3**. D**1** is used for automatic gain control for cable compensation in the SRU application and it is not in the AOU application. D**2** is used as an envelope detection for auto signal quality adaptive adjustment in the AOU application and as an additional signal detection in the SRU application. D**3** uses mixing down feature for power amplifier (PA) detection and alarm purposes in both applications.

c. Transceiver supports both open loop digital pre-distortion (DPD) and analog adaptive pre-distortion (APD) feature. All the filters in the transmitter chain have 2.5 time wider bandwidth than the signal bandwidth to support open loop DPD. The parameters needed for open loop DPD are characterized through calibration, then applies the polynomial parameters to the modem look up table (LUT) to correct and improve the non-linearity from the PA. APD is achieved through two couplers, P**1**, P**2** and a coupled down converted signal after the PA, in the transmitter chain, to a customized IC to achieve the improvement for the non-linearity from the PA.

d. The PA has the bias setting control capability to support reduced bias during low power level to support general "Green" application.

e. On the receiver side, the receiver signal level (RSL) chain uses a mixing mechanism and converter RF signal to the same Rx IF as the main signal, then uses a narrow band filter to reject interference signal to have a better signal indication accuracy.

f. The transceiver supports RF loopback capabilities. The loopback chain includes three couplers, two RF pads and a diode voltage controlled switch. When loopback commend is off, the diode switch is in high attenuation mode, and when the loopback commend is on, diode switch attenuation will be from high to low. RF loopback provides the radio to having a self-diagnosis capability.

g. Transceiver supports on-board local reference or a reference from digital board or from the IDU for future hitless and coherent applications.

In some implementations, a common transceiver is used for SRU and AOU.

FIG. **5** depicts a simplified cross-sectional view of the SRU according to some implementations of the present invention. The transceiver **23** is mounted to a casting **27** for heat sinking The interface card **21** is mounted to the same casting **27** as the transceiver **23**. The transceiver **23** and the interface card **21** are connected through a pair of mating connectors **22** and **24**.

One connector **24** of the pair is installed on the top of the interface card **21** and the other connector **24** is installed on the bottom of the transceiver **23**. Further detail can be seen in FIG. **6** that is an exploded view of the SRU shown in FIG. **5**.

FIG. **7** depicts a simplified cross-sectional view of the AOU according to some implementations of the present invention. The transceiver **43** is mounted to a casting **47** for heat sinking as in the SRU. In the AOU, the digital card **41** is mounted to its own casting **49** for heat sinking Since the digital card **41** is larger than the interface card **21** and generates much more heat, it cannot be mounted to the same casting as the transceiver **43**. To simplify the connection between the transceiver **43** and the digital card **41**, the connector **44** on the transceiver **43** is relocated from the bottom of the transceiver **43** to the top of the transceiver **43**. There is a dual footprint for the connector **44** with one footprint on the bottom to be utilized when the transceiver **43** is installed in an SRU and with one footprint on the top to be utilized when the transceiver **43** is installed in an AOU. A flexible circuit **46** (represented by the white double-sided arrow) is used in the AOU to bridge the gap between the connectors **42** and **44** of the digital card **41** and the transceiver **43**. By relocating the connector, a common transceiver is used for the SRU and AOU. Further detail can be seen in FIG. **8**, which is an exploded view of the AOU.

FIG. **9** depicts the top and bottom of a transceiver and the position of the connector for use in the SRU and AOU according to some implementations of the present invention. In some implementations, the present invention proposes a common diplexer for the SRU and AOU.

The common diplexer **25**/**45** can be seen in FIGS. **5** and **7**. The transmit port and the receive port of the diplexer **25**/**45** connect to the transmit port and receive port of the transceiver **23**/**43**. Since the transceiver and diplexer are both common to the SRU and AOU, the connection between the two is also common. In the SRU, the diplexer common port extends out of a hole in the SRU enclosure and connects to the antenna. For the AOU, the diplexer common port is not long enough to extend out of a hole in the AOU enclosure casting due to the location of the digital card between the diplexer and the casting and also due to the addition of cooling fins to this casting. In order to utilize a common diplexer a Waveguide Extension is added. This extension is a passive component that bridges the distance between the diplexer and the antenna. Further detail can be seen in FIGS. **6** and **8**.

In some implementations, the present invention proposes a common antenna interface and a common mounting mechanics for the SRU and AOU.

The common antenna **30** can be seen in FIGS. **5** and **7**. The common port of the diplexer connects to the antenna to pass the transmit and the receive signals between the antenna and the SRU and AOU. This connection is a waveguide connection. For the SRU, the antenna feed mates directly to the diplexer through the opening in the casting for the diplexer common port. For the AOU, the antenna feed mates to the waveguide extension which mates to the diplexer. Refer to FIGS. **6** and **8** for more detail. The SRU casting has four mounting posts that are used to mount the SRU to the antenna using screws. The AOU has four similar mounting posts that are in the same location relative to the antenna feed interface as on the SRU. This configuration allows the use of a common antenna interface and common mounting mechanics for the SRU and AOU.

In some implementations, the present invention proposes common software and common control for SRU and AOU

FIG. **10** depicts a block diagram of RF components control software according to some implementations of the present invention. The RF components control software controls RF Hardware and provides generic interface for system configuration. Software design includes following key points:

a. Design isolates Application Modules from Operation System by using OS Abstract Layer as shown in FIG. **10**, so RF Components Control Software can use different Operation Systems as a base in case of AOU and SRU. It is usually required since complexity of AOU and IDU software is different.
b. Adapter module implements generic interface for communication with IDU via telemetry channel in case of ODU or with other modules outside RF Components Control Software in case of AOU via inter-task communication mechanism.
c. All bandwidth and modulation dependant data like, maximum power level, attenuation ranges for attenuators, correction factors for detectors reading, etc. are stored separately from RF Components Control Software in form of Bandwidth/Modulation Profiles. Profiles can be updated separately from the software that simplifies software development and maintenance. For better system resources utilization, dedicated Parameter module loads only one particular profile for current configuration as shown on FIG. **11**. Each frequency band has its own set of Bandwidth/Modulation Profiles, so as soon as new band hardware design follows common system architecture, only new set of Bandwidth/Modulation Profiles needs to be introduced to make software support new hardware. No changes in RF Components Control Software are required.

In some implementations, the present invention proposes a common calibration routine, common Automatic Test Equipment (ATE) and common test flow for both SRU and AOU. FIG. **12** depicts a flow chart illustrating a testing and integration workflow for both the SRU and the AOU according to some implementations of the present invention. SRU includes four basic parts, diplexer, transceiver (TRX), interface card (INFC) and SRU mechanics. Diplexer, TRX and INFC first go through module own pass/fail test station, then TRX, INFC and SRU mechanics integrated together as a Radio Frequency Unit (RFU), RFU goes through RF and DPD calibration, then integrated with diplexer becomes a frequency band dependent part and go through final SRU test flow. AOU has the similar test flow, and sharing TRX and diplexer exactly with SRU.

ATE flow chart includes the following key ideas:

a. TRX and Diplexer designed mechanically, electronically and tested for both SRU and AOU families
b. TRX module test and calibration includes regular RF pass/fail test, RF calibration at room temperature, then applies correction factors for temperature range, which covers from −33° C. to +55° C., frequency range, output power, 30 dB dynamic range for Pout and 70 dB dynamic range for the receiver, various BW, from 5 Mhz up to 56 MHz, and various modulation from QPSK up to 1024 QAM.
c. TRX module performs the open loop digital pre-distortion (DPD) calibration at room temperature, then applies correction factor for temperature range, various output power levels, various frequency, various bandwidth and various baud rates.
d. TRX RF and DPD calibration data stored in the local EEprom, and data will be used during radio operation per radio setting and automatically adjusted per on board temperature sensor, frequency, power level, bandwidth and capacity.

Compared with traditional SRU and AOU architecture, the flexible and unified radio architecture design of the present application has the following key advantages:

a. Within the SRU family, the common interface card is used for all frequency bands.

The typical license band includes frequency band of 6 GHz, 7 GHz, 8 GHz, 10 GHz, 11 GHz, 13 GHz, 15 GHz, 18 GHz, 23 GHz, 26 GHz, 28 GHz, 32 GHz, 38 GHz and 42 GHz.

b. Within the AOU family, the common digital card is used for all frequency bands. The same frequency bands apply to SRU.

c. The common diplexer is used for both SRU and AOU platforms.

d. The common transceiver is used for both SRU and AOU platforms.

e. The common software is used within the SRU platform and the AOU platform.

f. The common software engine with different drivers between SRU and AOU platforms.

g. The common mechanics is used within the SRU platform and the AOU platform.

h. The common antenna interface is used for both the SRU and AOU platforms.

i. The common mounting mechanism is used for both the SRU and AOU platforms.

j. The common key TRX RF and DPD calibration routine is used for both the SRU and AOU platforms.

k. The common test flow and integration flow is used for both the SRU and AOU platforms.

l. Many unique features designed in transceivers including integrated APD/DPD, down converted high dynamic linear temperature compensated RF detection, integrated RF loopback, smart PA bias setting, and common reference for hitless and coherent features.

Overall, the architecture of the SRU and AOU is to enable the use of components and circuitry on the transceiver for both the SRU and AOU. This design conserves valuable area on the transceiver and allows the transceiver size to be minimized. Cost savings are also realized by reducing mechanical component sizes. The use of a common transceiver, diplexer, and antenna greatly reduces the number of unique components that must be designed, tested, and stocked. This reduction significantly reduces the time to market and design resources required. Economies of scale are realized in manufacturing since the volume of the common assemblies is increased.

In some implementations, the above-described methods and their variations may be implemented as computer software instructions or firmware instructions. Such instructions may be stored in an article with one or more machine-readable storage devices connected to one or more computers or integrated circuits or digital processors such as digital signal processors, microprocessors, or micro-control units (MCU), and the instructions may perform the transmission method for transmitting machine type communication (MTC) data. In addition, the method may be applied to any MTC capable mobile communications device supporting the wideband code division multiple access (WCDMA) technology and/or the LTE technology. Other variations and enhancements are possible based on what is mentioned here.

Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. The terminology used in the description of the invention herein is for the purpose of describing particular implementations only and is not intended to be limiting of the invention. As used in the description of the invention and the appended claims, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes," "including," "comprises," and/or "comprising," when used in this specification, specify the presence of stated features, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, operations, elements, components, and/or groups thereof.

As used herein, the term "if" may be construed to mean "when" or "upon" or "in response to determining" or "in accordance with a determination" or "in response to detecting," that a stated condition precedent is true, depending on the context. Similarly, the phrase "if it is determined [that a stated condition precedent is true]" or "if [a stated condition precedent is true]" or "when [a stated condition precedent is true]" may be construed to mean "upon determining" or "in response to determining" or "in accordance with a determination" or "upon detecting" or "in response to detecting" that the stated condition precedent is true, depending on the context.

Although some of the various drawings illustrate a number of logical stages in a particular order, stages that are not order dependent may be reordered and other stages may be combined or broken out. While some reordering or other groupings are specifically mentioned, others will be obvious to those of ordinary skill in the art and so do not present an exhaustive list of alternatives. Moreover, it should be recognized that the stages could be implemented in hardware, firmware, software or any combination thereof.

The foregoing description, for purpose of explanation, has been described with reference to specific implementations. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The implementations were chosen and described in order to best explain principles of the invention and its practical applications, to thereby enable others skilled in the art to best utilize the invention and various implementations with various modifications as are suited to the particular use contemplated. Implementations include alternatives, modifications and equivalents that are within the spirit and scope of the appended claims. Numerous specific details are set forth in order to provide a thorough understanding of the subject matter presented herein. But it will be apparent to one of ordinary skill in the art that the subject matter may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the implementations.

We claim:

1. A transceiver used in a radio unit for wireless communication, comprising:

a circuitry board including a transmitter and a receiver;

a first connector on a first side of the circuitry board, wherein the first connector is configured to be connected to an interface card;

a second connector on a second side of the circuitry board, wherein the second side is opposite the first side and the second connector is configured to be connected to a digital card via a flexible circuit; and

a pair of transmit port and receive port located on the second side of the circuitry board, wherein the transmit port is coupled to the transmitter and the receive port is coupled to the receiver, respectively.

2. The transceiver of claim **1**, wherein, when the transceiver is part of a split-mount radio unit (SRU), the first connector is connected to the interface card and the second connector is not in use.

3. The transceiver of claim **1**, wherein, when the transceiver is part of an all-outdoor radio unit (AOU), the second connector is connected to the digital card and the first connector is not in use.

4. The transceiver of claim **1**, wherein the first connector and the second connector are configured not to be in use concurrently.

5. The transceiver of claim **1**, wherein the first connector and the second connector have substantially mirror-imaged locations on the first and second sides of the circuitry board.

6. The transceiver of claim **1**, wherein the pair of transmit port and receive port are configured to be connected to a pair of transmit port and receive port of a diplexer.

7. The transceiver of claim **1**, wherein the transmitter further includes a plurality of detectors configured in a serial connection, a circuitry supporting open loop digital pre-distortion and analog adaptive pre-distortion, and a power amplifier.

8. A split-mount radio unit, comprising:

an indoor unit; and

an outdoor unit that is connected to the indoor unit via a cable, wherein the outdoor unit further includes:

an enclosure including a pair of first and second castings, wherein the first casting includes a heat sink;

an interface card mounted on an inside surface of the first casting, wherein the interface card includes a connector on a surface opposite the inside surface of the first casting;

a transceiver including a transmitter and a receiver mounted on the inside surface of the first casting, wherein the transceiver includes a first connector on a first side of the transceiver facing the inside surface of the first casting and a second connector and a pair of transmit port and receive port on a second side of the transceiver opposite the first side of the transceiver and the second connector is configured to be connected to a digital card via a flexible circuit, the first connector is connected to the connector of the interface card and the second connector is not in use and the transmit port is coupled to the transmitter and the receive port is coupled to the receiver, respectively;

a diplexer including a pair of transmit port and receive port on a surface facing the second side of the transceiver and a common port on an opposite surface facing an inside surface of the second casting, wherein the pair of transmit port and receive port of the diplexer are connected to the corresponding pair of transmit port and receive port of the transceiver; and

an antenna outside the enclosure, wherein the antenna includes a port connected to the common port of the diplexer through a hole of the second casting.

9. The split-mount radio unit of claim **8**, wherein the cable connecting the indoor unit and the outdoor unit is an RG-8 cable having a length ranging from a few feet up to 1000 feet.

10. The split-mount radio unit of claim **8**, wherein the first connector and the second connector have substantially mirror-imaged locations on the first and second sides of the transceiver.

11. The split-mount radio unit of claim **8**, wherein the first connector and the second connector are configured not to be in use concurrently.

12. The split-mount radio unit of claim **8**, wherein the transmitter further includes a plurality of detectors configured in a serial connection, a circuitry supporting open loop digital pre-distortion and analog adaptive pre-distortion, and a power amplifier.

13. An all-outdoor radio unit, comprising:

an enclosure including a pair of first and second castings, wherein each of the pair of first and second castings includes a heat sink;

a transceiver mounted on an inside surface of the first casting, wherein the transceiver includes a first connector on a first side of the transceiver facing the inside surface of the first casting and a second connector and a pair of transmit port and receive port on a second side opposite the first side of the transceiver;

a diplexer including a pair of transmit port and receive port on a first side of the diplexer facing the inside surface of the first casting and a common port on an opposite side of the diplexer facing an inside surface of the second casting, wherein the pair of transmit port and receive port of the diplexer are connected to the corresponding pair of transmit port and receive port of the transceiver;

a digital card mounted on the inside surface of the second casting, wherein the digital card includes a hole near its center and a connector on a surface opposite the inside surface of the second casting for connecting to the second connector of the transceiver via a flexible circuit; and

an antenna outside the enclosure, wherein the antenna includes a port connected to the common port of the diplexer via a waveguide connection through a hole of the second casting and the hole near the center of the digital card, respectively.

14. The all-outdoor radio unit of claim **13**, wherein the first connector and the second connector have substantially mirror-imaged locations on the first and second sides of the transceiver, respectively.

15. The all-outdoor radio unit of claim **13**, wherein the first connector and the second connector are configured not to be in use at the same time.

16. The all-outdoor radio unit of claim **13**, wherein the transmitter further includes a plurality of detectors configured in a serial connection, a circuitry supporting open loop digital pre-distortion and analog adaptive pre-distortion, and a power amplifier.

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